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EXCELENCIA SEVERO OCHOA

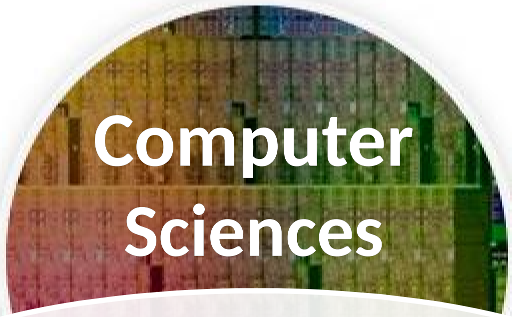
Generation of initial conditions in climate prediction

Valentina Sicardi
On behalf of the Climate Prediction Group

12 th RES Users’s conference.Valencia- 20- September- 2018

Mission of BSC Scientific Departments

Computer Sciences



To influence the way machines are built, programmed and used: programming models, performance tools, Big Data, computer architecture, energy efficiency

Earth Sciences

To develop and implement global and regional state-of-the-art models for short-term air quality forecast and long-term climate applications

Life Sciences

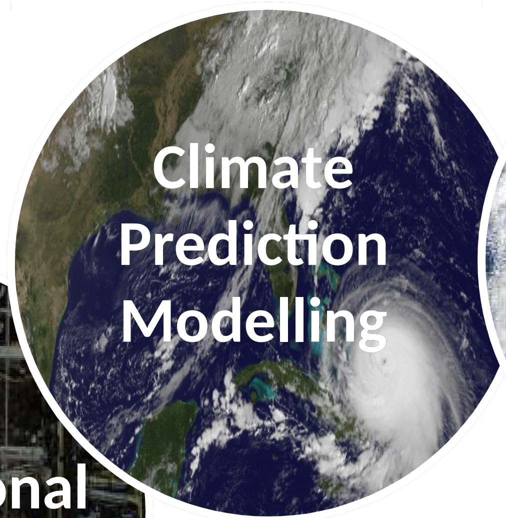
To understand living organisms by means of theoretical and computational methods (molecular modeling, genomics, proteomics)

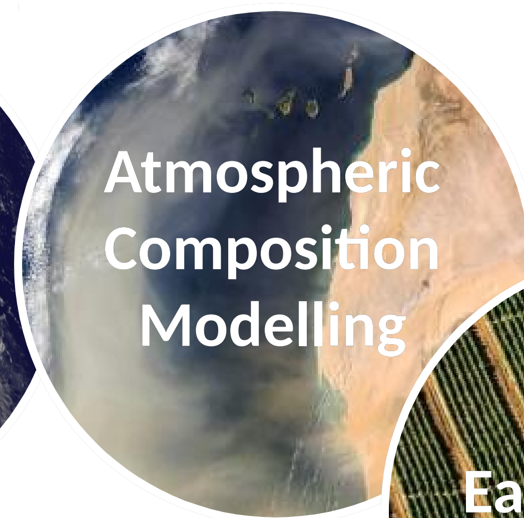
CASE

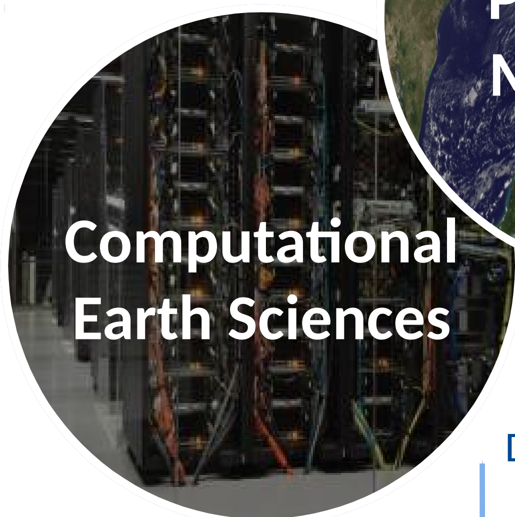
To develop scientific and engineering software to efficiently exploit super-computing capabilities (biomedical, geophysics, atmospheric, energy, social and economic simulations)

Earth Science Department

Environmental modelling and forecasting, with a particular focus on weather, climate and air quality







Director: **Francisco Doblas-Reyes**

- About 80 scientists
- Leading: H2020 project, COPERNICUS contract, ERC Consolidator Grant and hosts an AXA Chair

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Weather vs Climate predictions

Weather prediction — temporal horizon → **around 10 days**

Climate prediction — temporal horizon → **from weeks to decades**

Why?

- ➢ Chaotic nature of the atmosphere limits the weather forecast horizon
- ➢ Some elements of the climate system change slower than the atmosphere

ocean

sea ice

soil moisture

The ocean is still predictable even when the atmosphere is not!

We can predict how the atmosphere might respond to the oceans.

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Weather vs Climate predictions

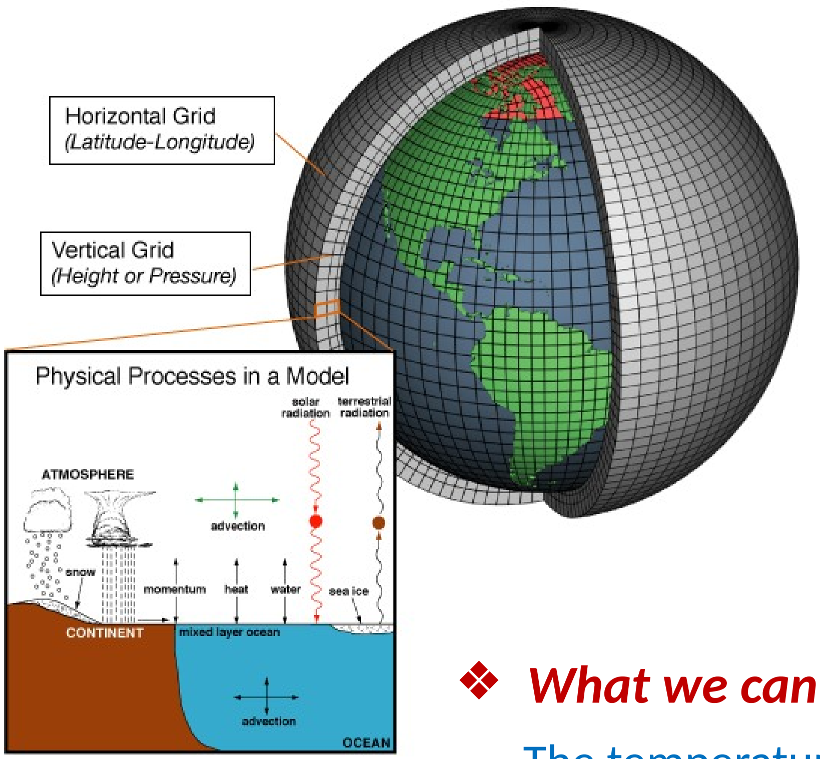

Image source: NOAA

Coupled climate model

(atmosphere + land + ocean + sea ice)

initialised with current observations

Predictions for the next few week/ season

❖ ***What we can NOT expect from climate predictions***

The temperature in Albacete on 27th February

✓ ***What we can expect from climate predictions***

How likely next winter is going to be colder/warmer than normal

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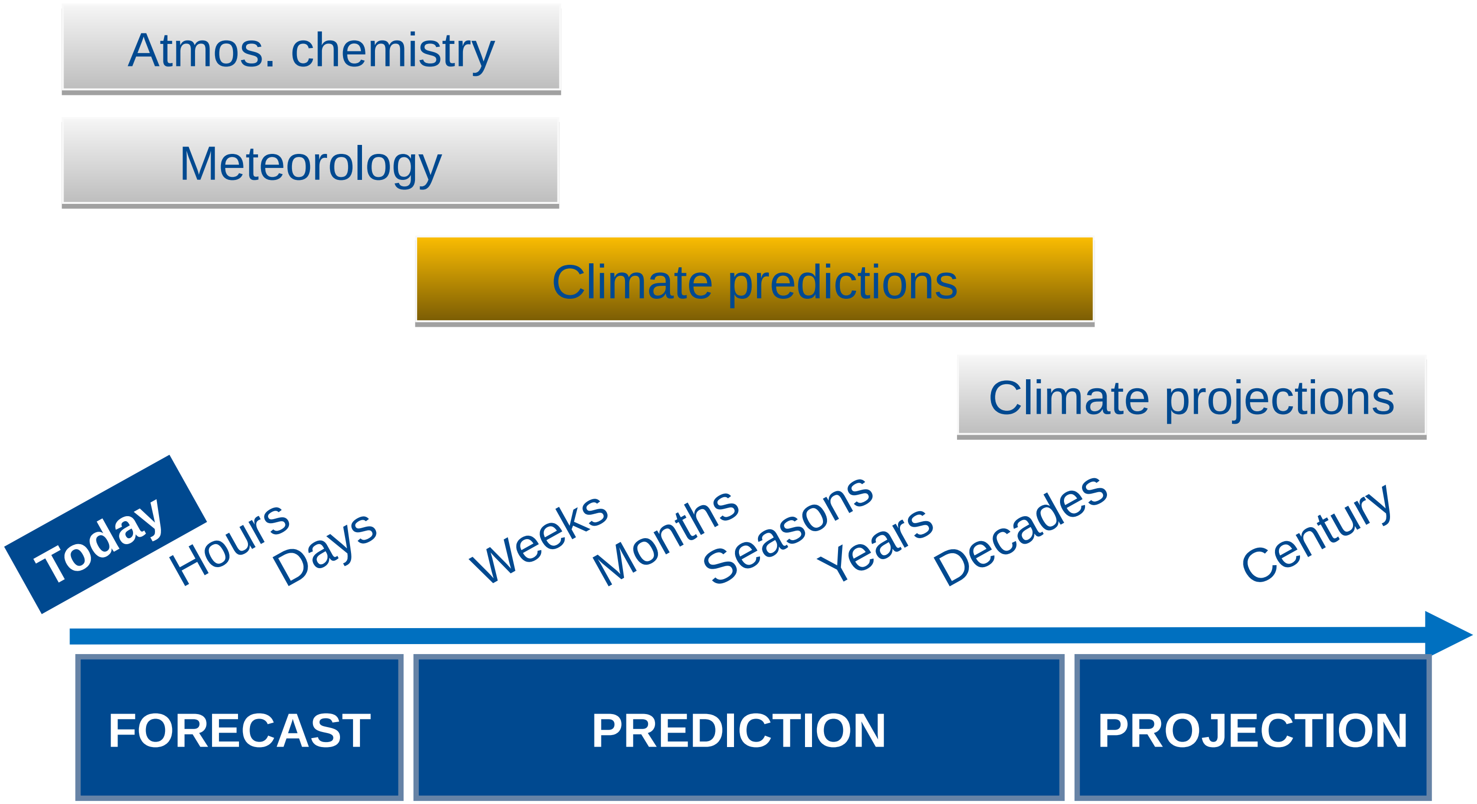
Temporal Scales



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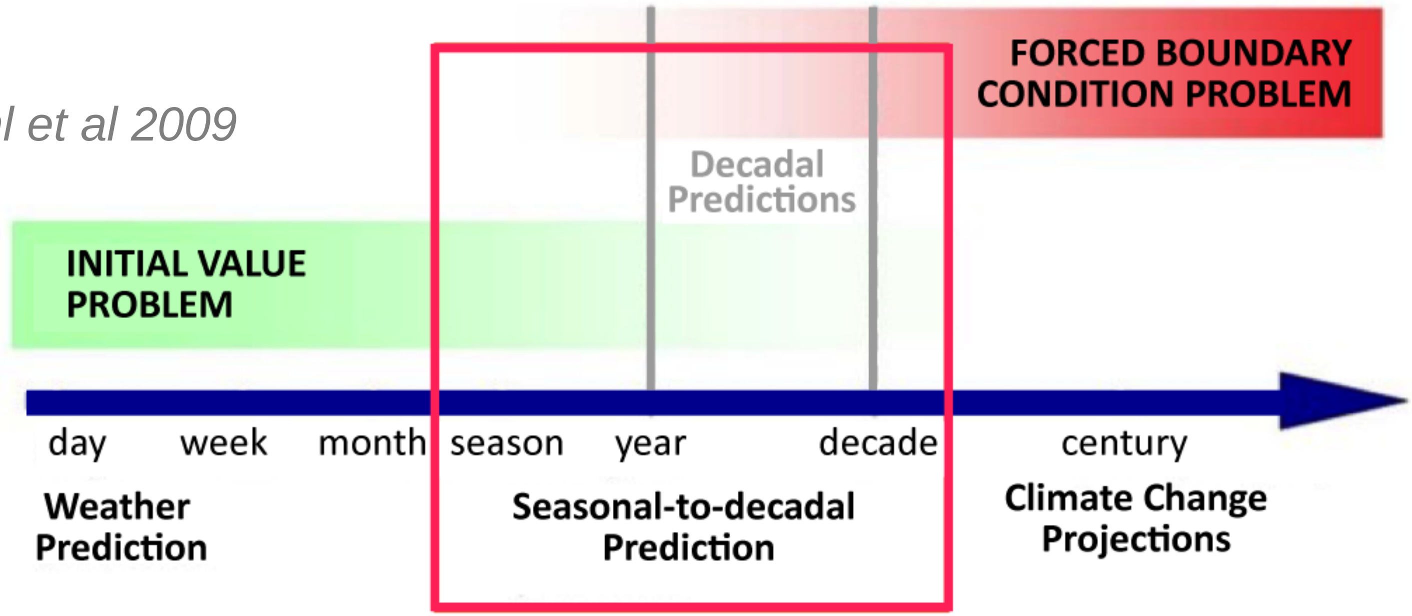
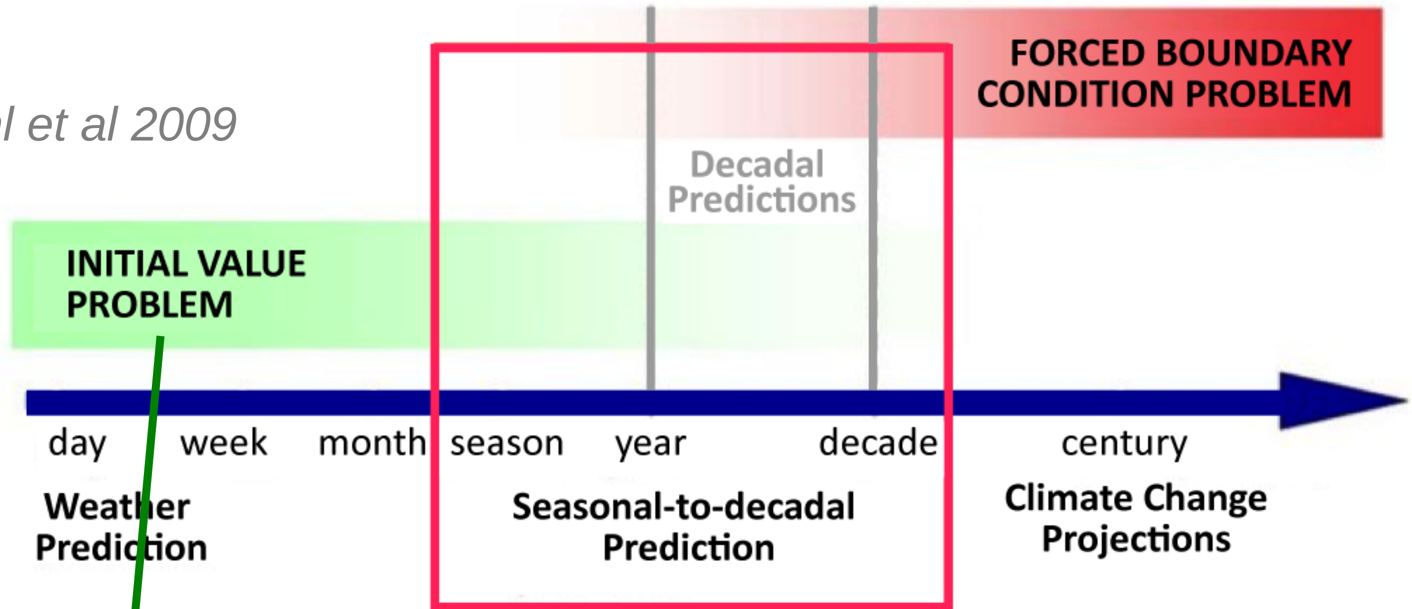
Climate Prediction

Meehl et al 2009

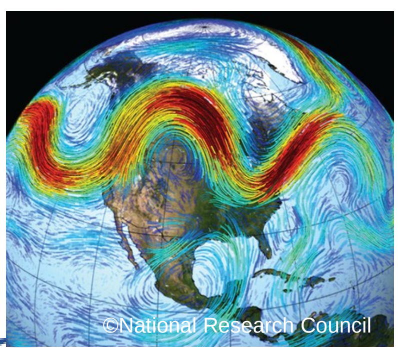


Climate Prediction

Meehl et al 2009



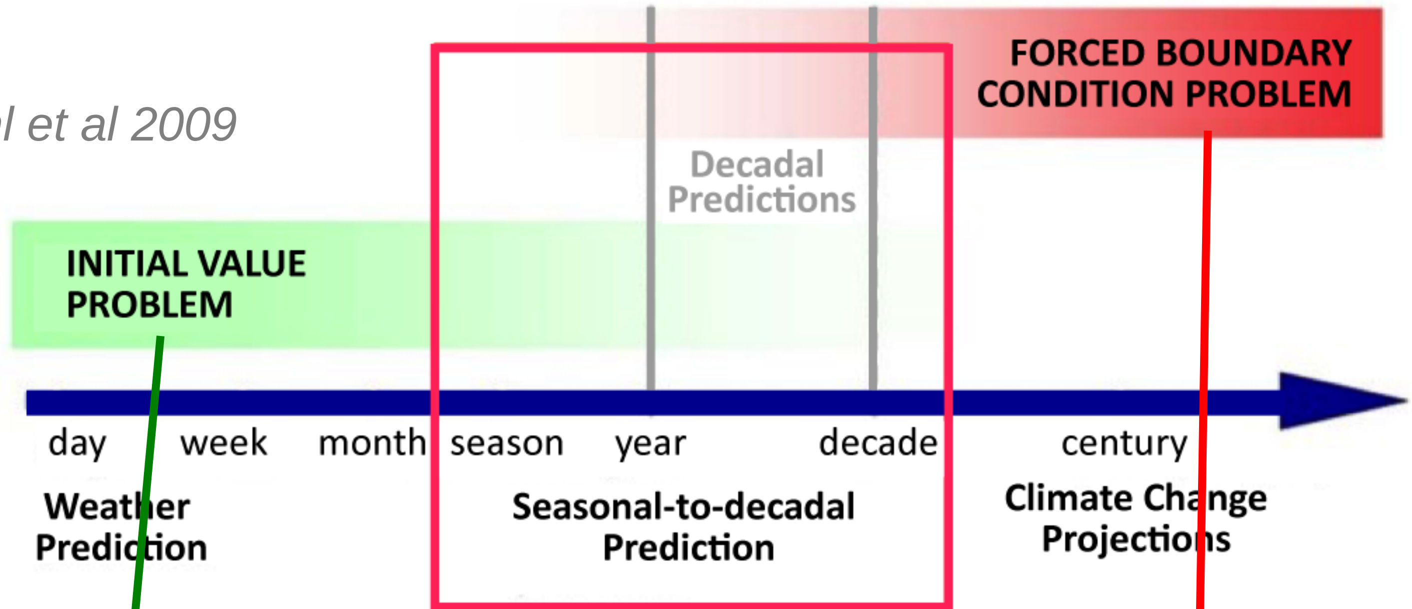
Current Meteorological state



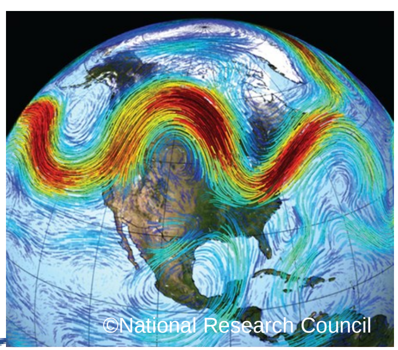
Correct Initialization of internal sources of predictability

Climate Prediction

Meehl et al 2009



Current Meteorological state



Correct Initialization of internal sources of predictability

Solar Activity

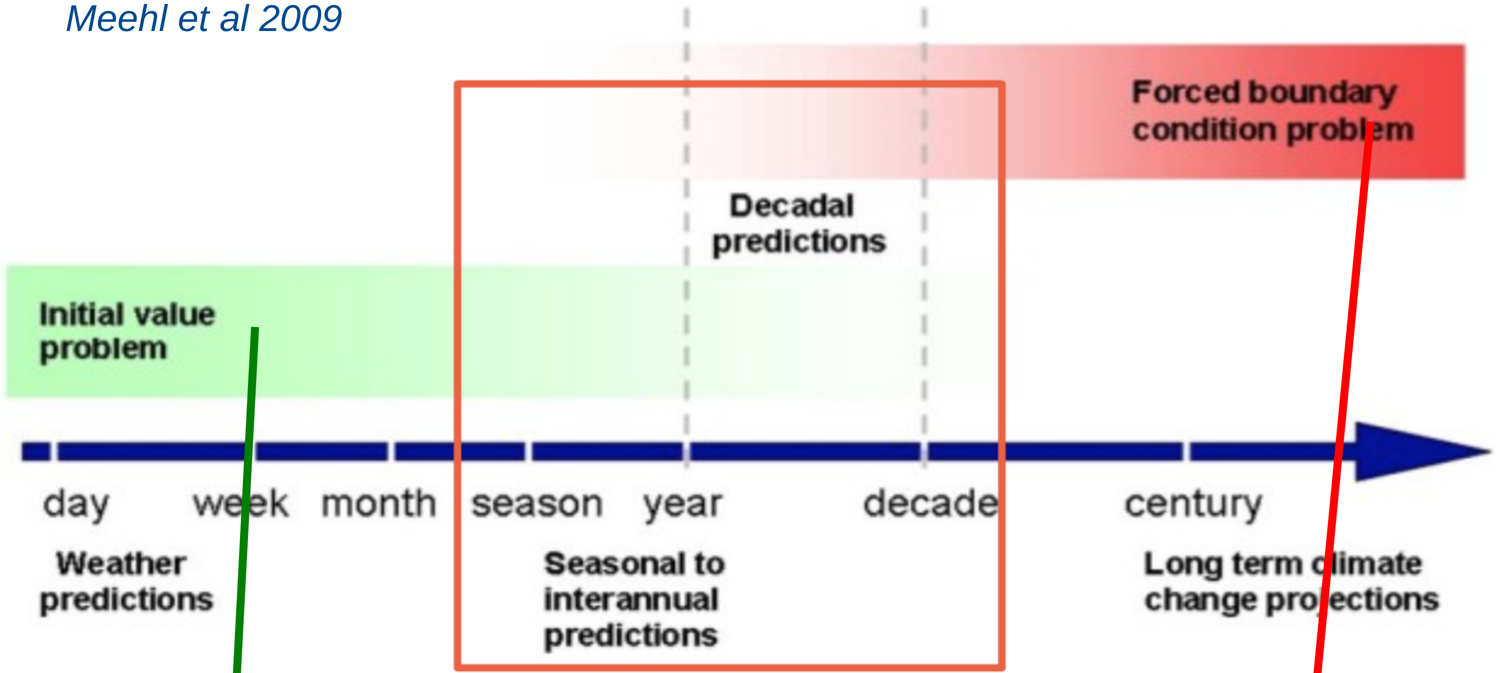
GHGs

Volcanic Aerosols

Good guess of future changes in the forcing

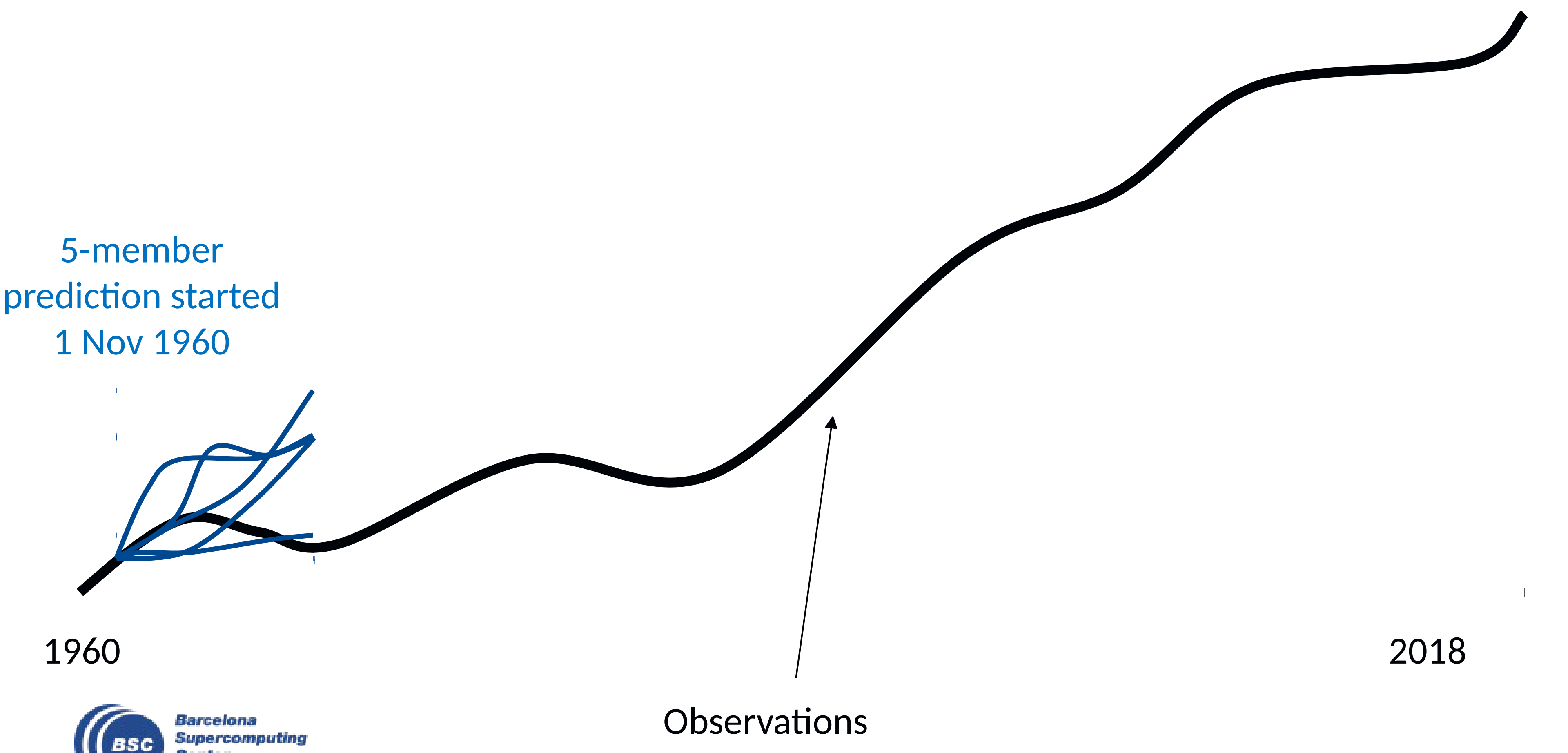
Climate Prediction

Meehl et al 2009

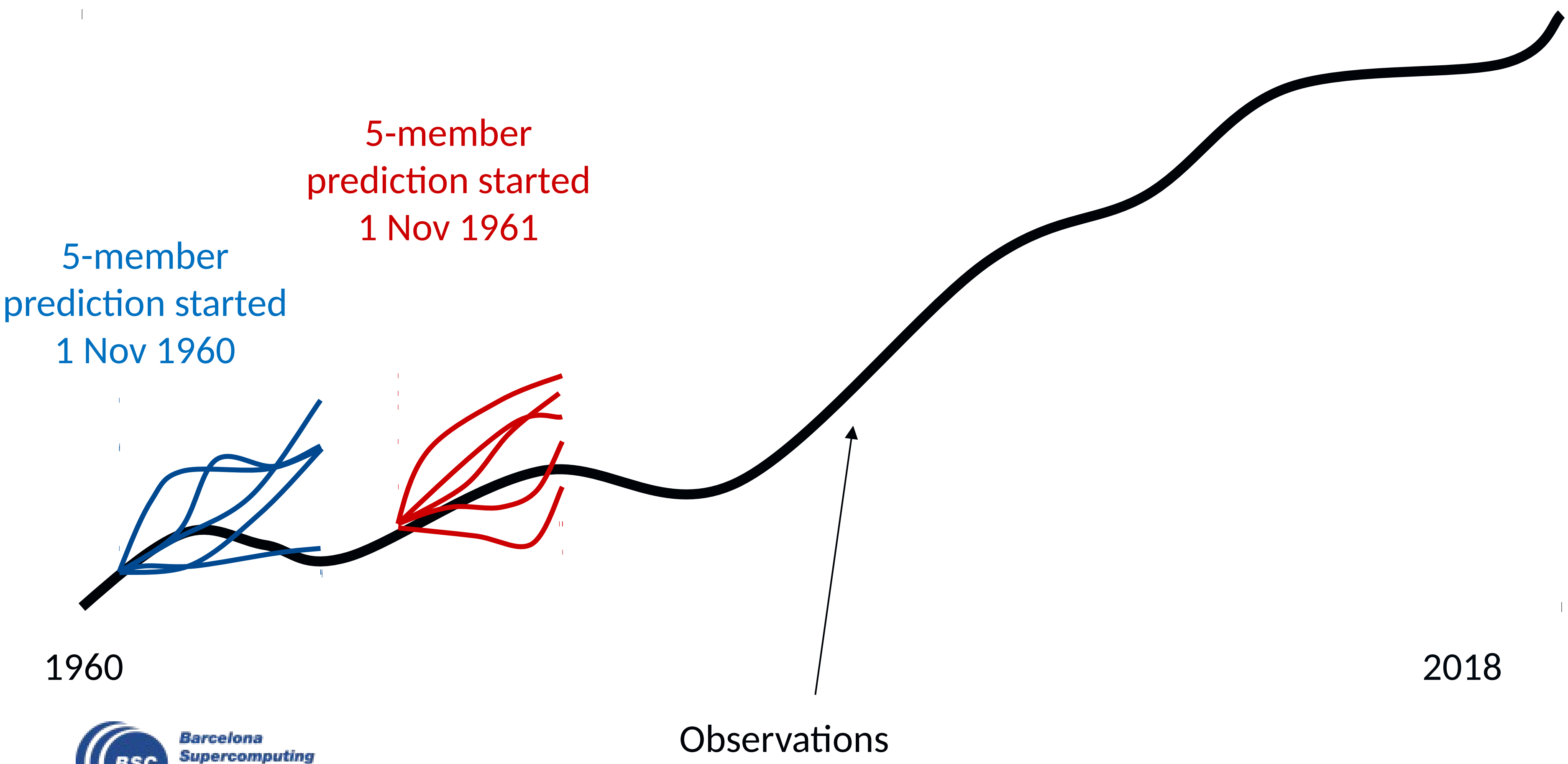


1) Internal sources of predictability?

2) Role of forcings?


5-member
prediction started
1 Nov 1960
1960
2018
Observations

Decadal Climate Prediction



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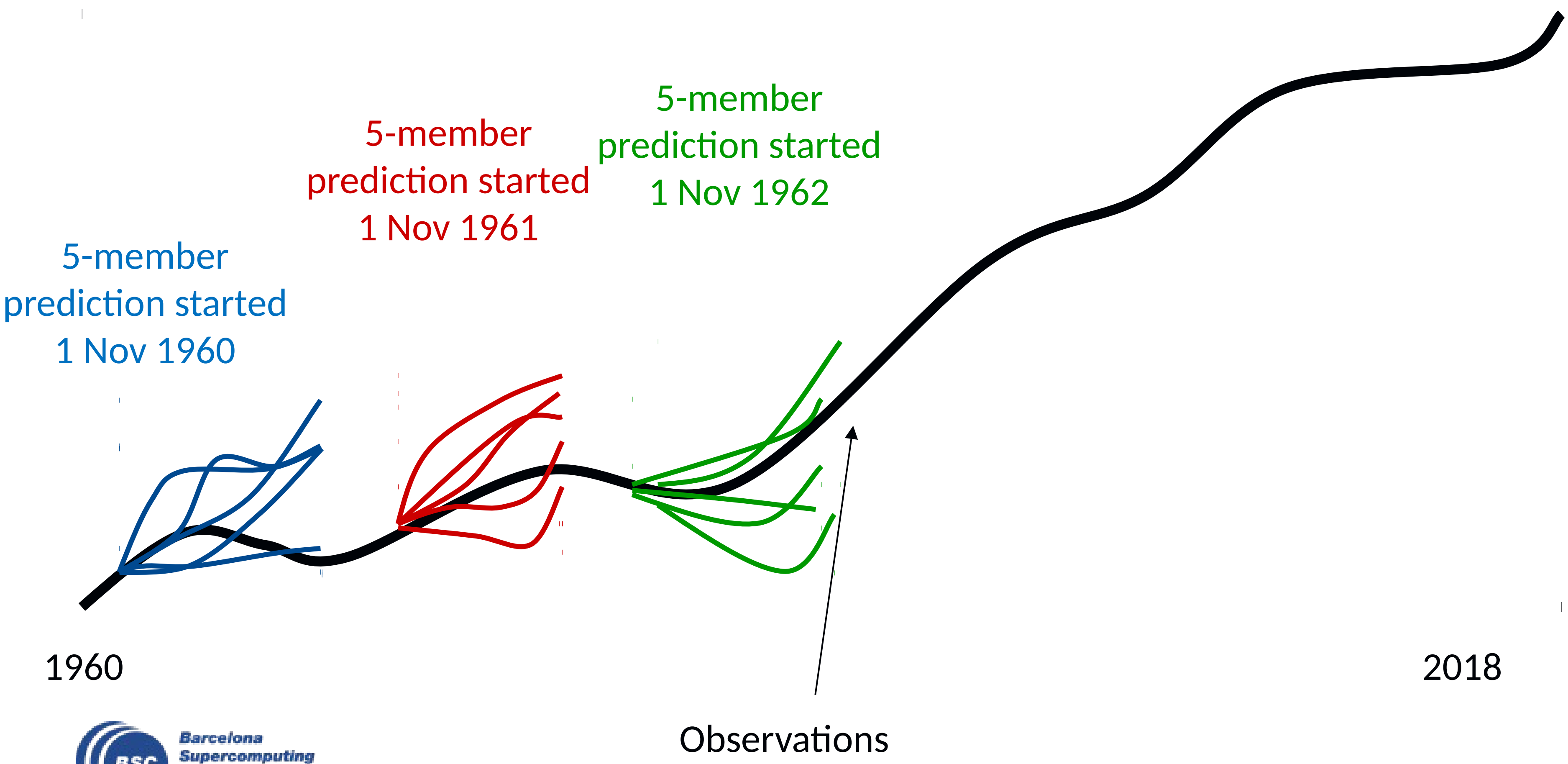
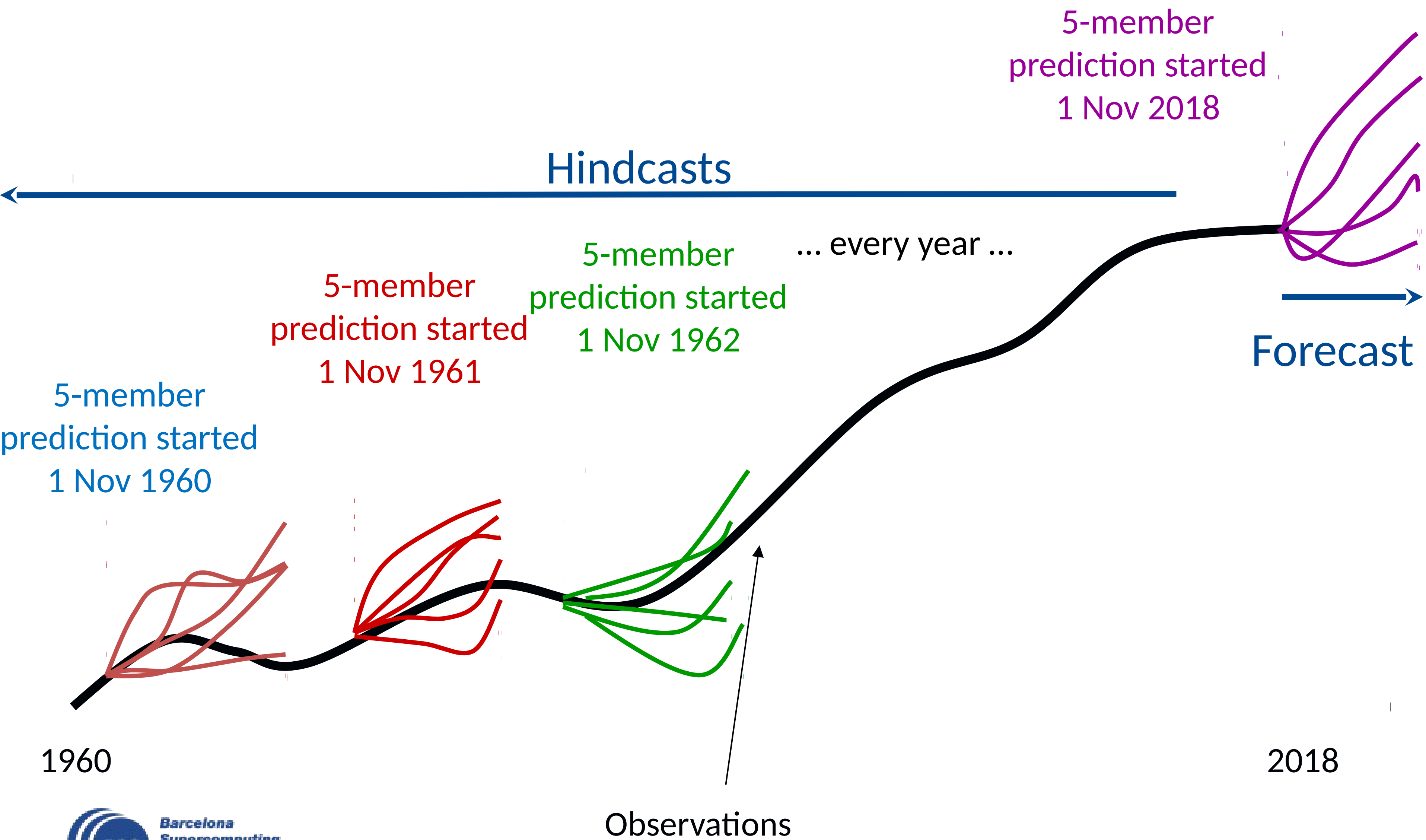
Decadal Climate Prediction



Decadal Climate Prediction



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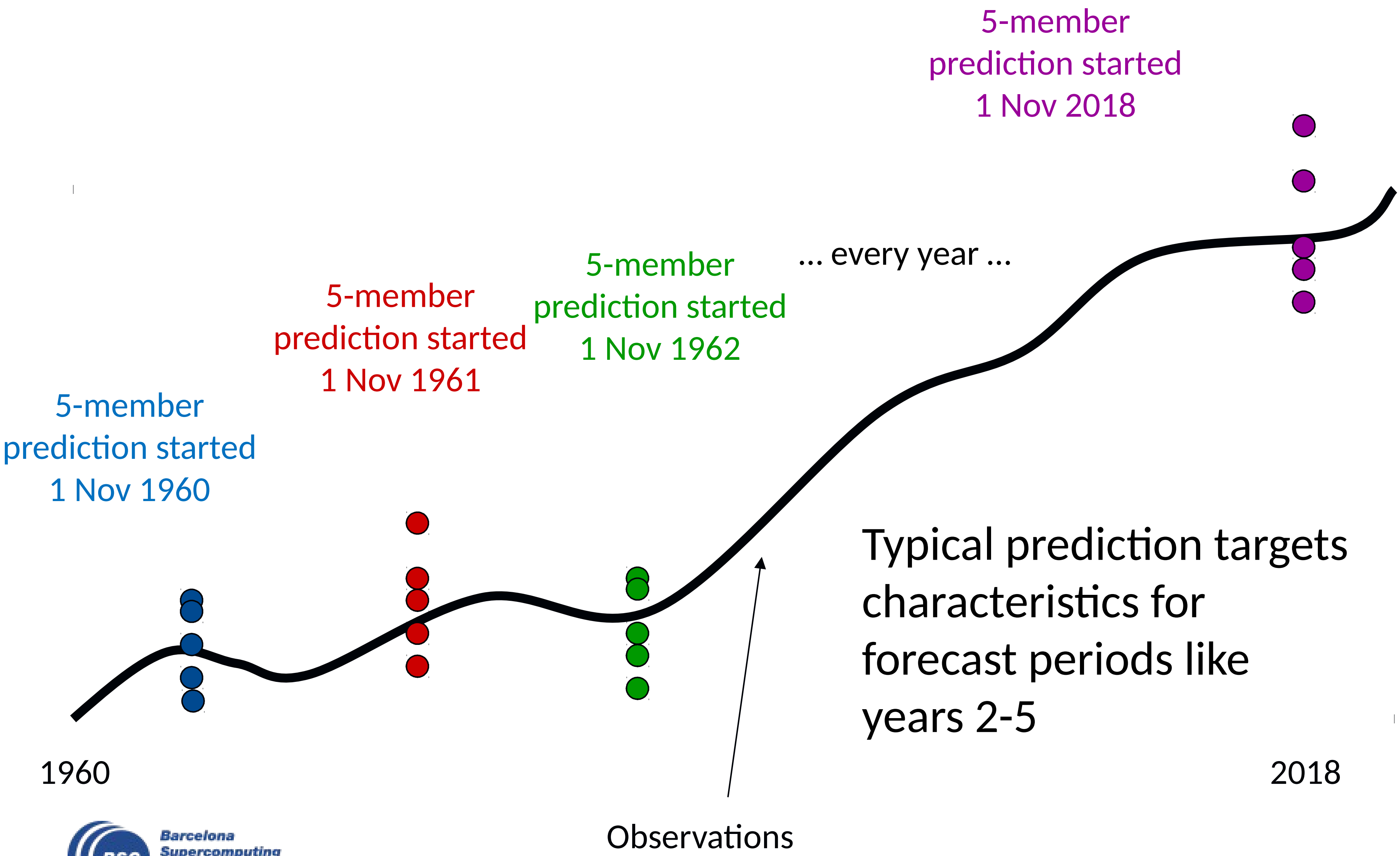
Decadal Climate Prediction



Typical prediction targets characteristics for forecast periods like years 2-5

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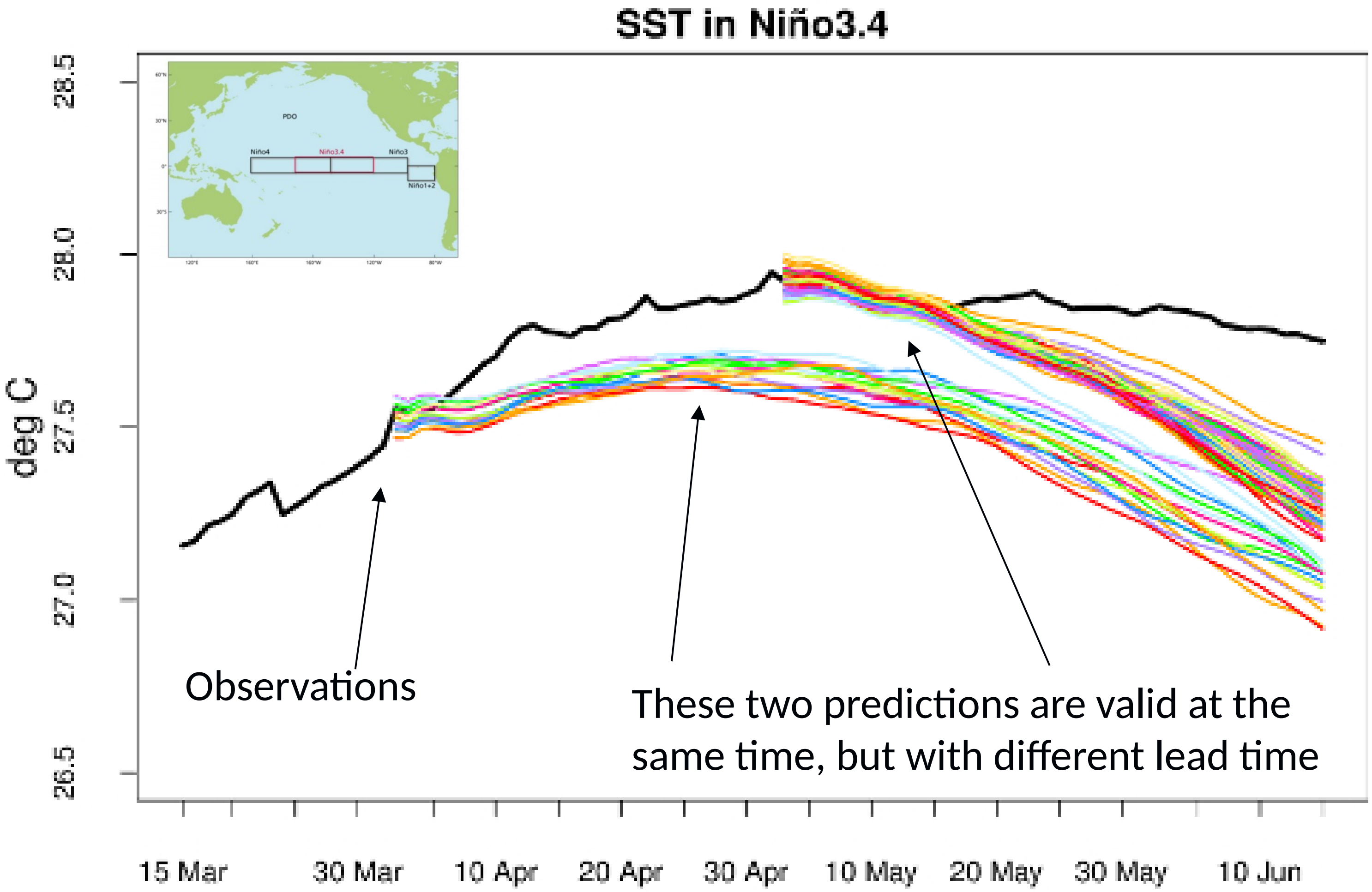
Model drift

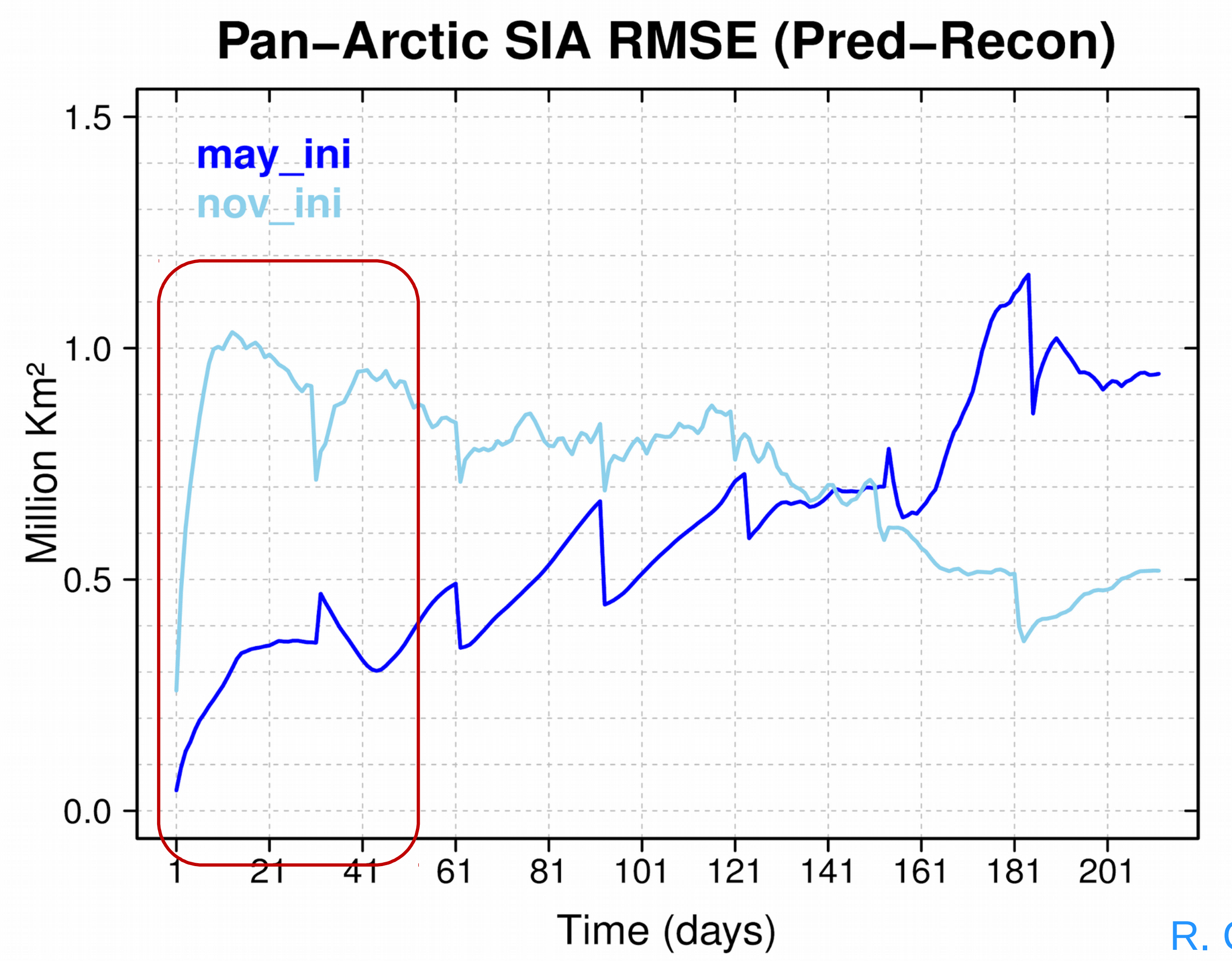
Drift, which is not necessarily monotonic, is the result of the model tending towards its own attractor.



SST predictions over the Niño3.4 region from ECMWF System 4 starting on the 1st of April and May of a particular year.

Initial Shock

Initial shock is the result of the model rejecting a part of the initial conditions or the incompatibility of the ic of the model components (ice, ocean, atmosphere)

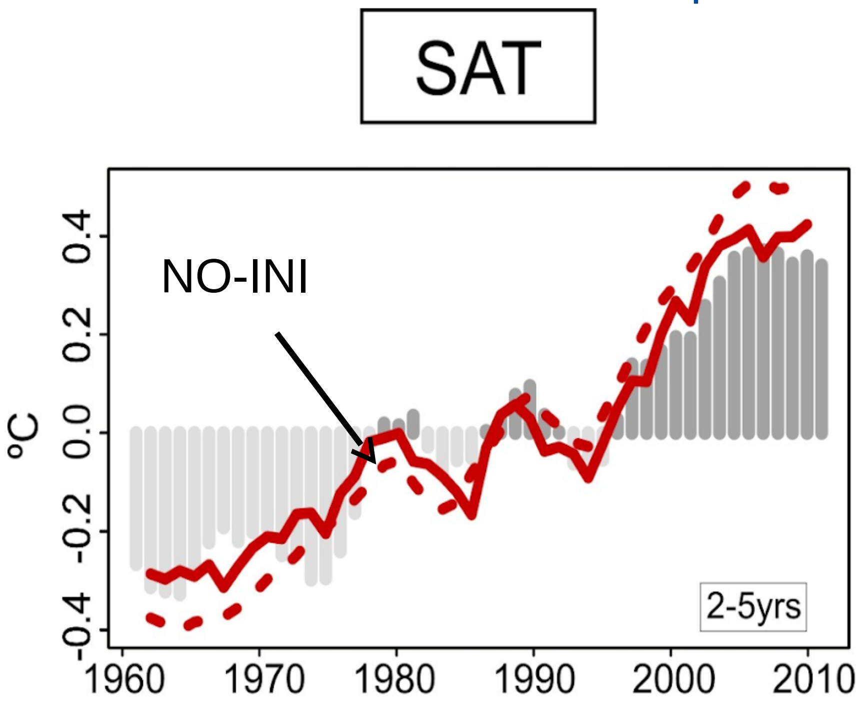


R. Cruz

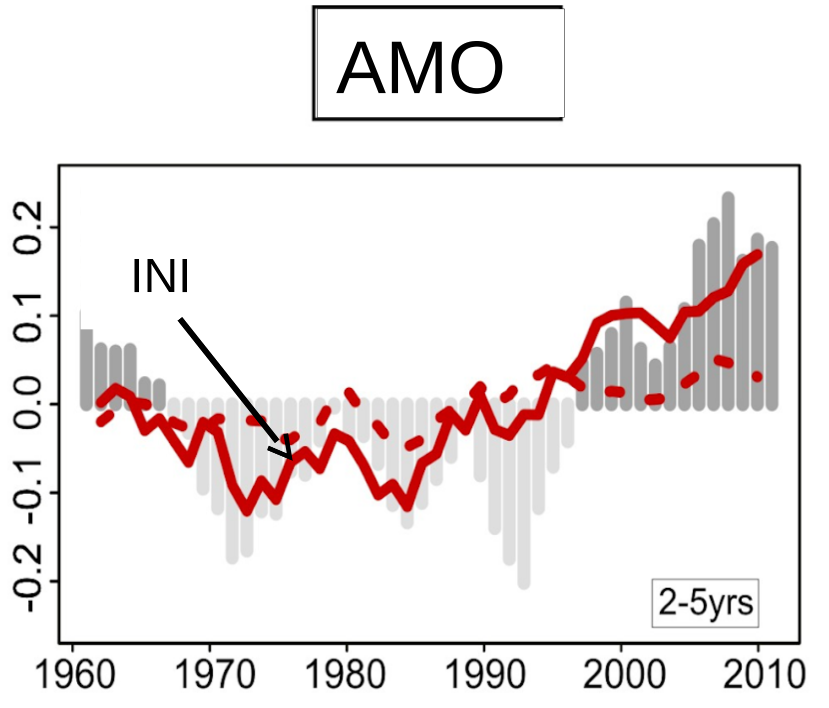
Impact of ocean initialization

Global-mean surface air-temperature ('global warming') and Atlantic Multidecadal Oscillation (AMO) for forecast years 2-5

Global mean surface air-temperature

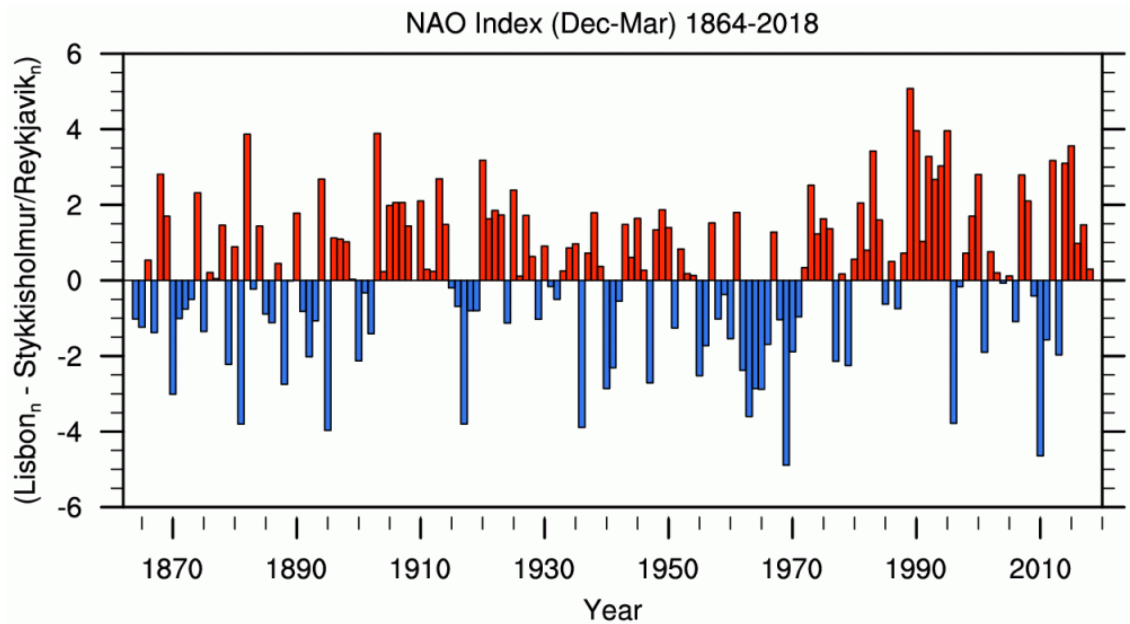


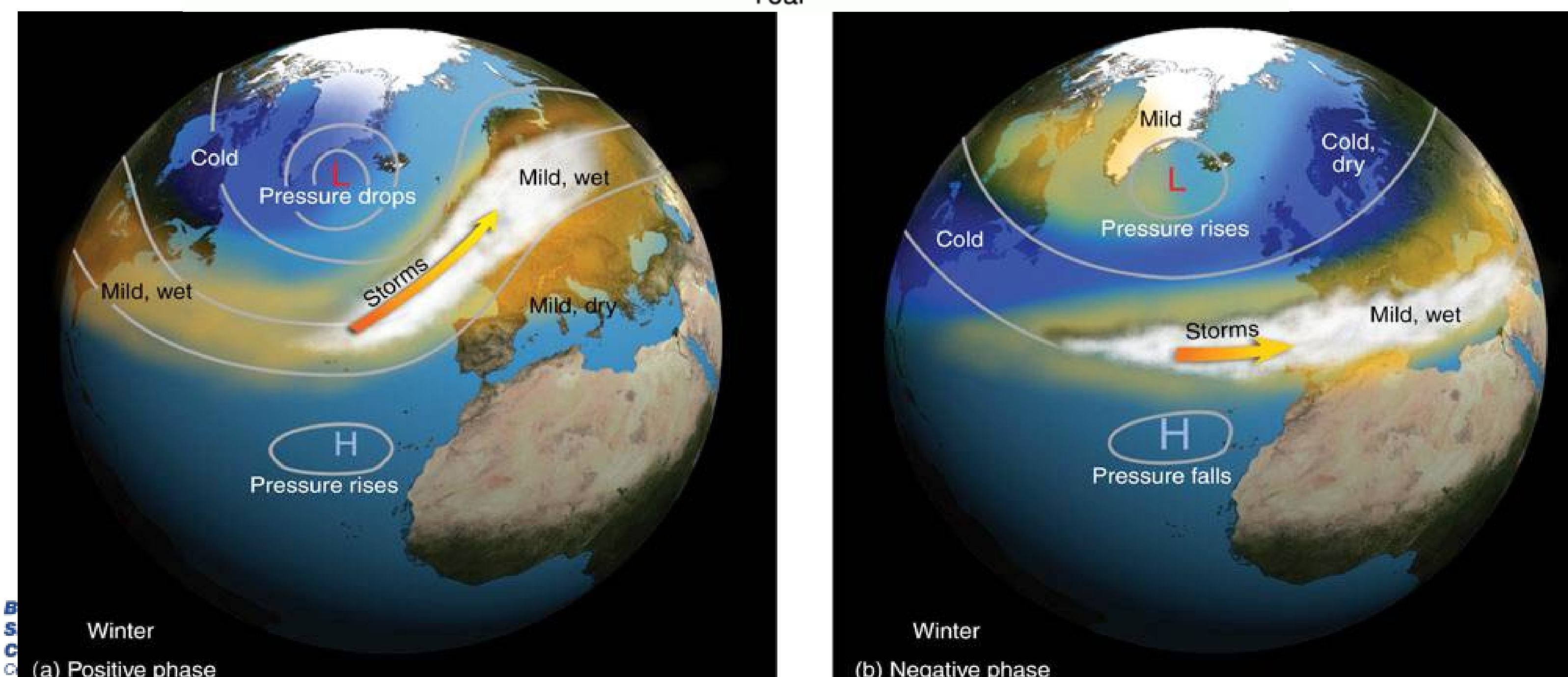
Atlantic Multidecadal Oscillation



Initialised simulations reproduce the global temperature and some of the AMV tendencies and suggest that initialization corrects the forced model response and phases in internal variability.

V. Guemas





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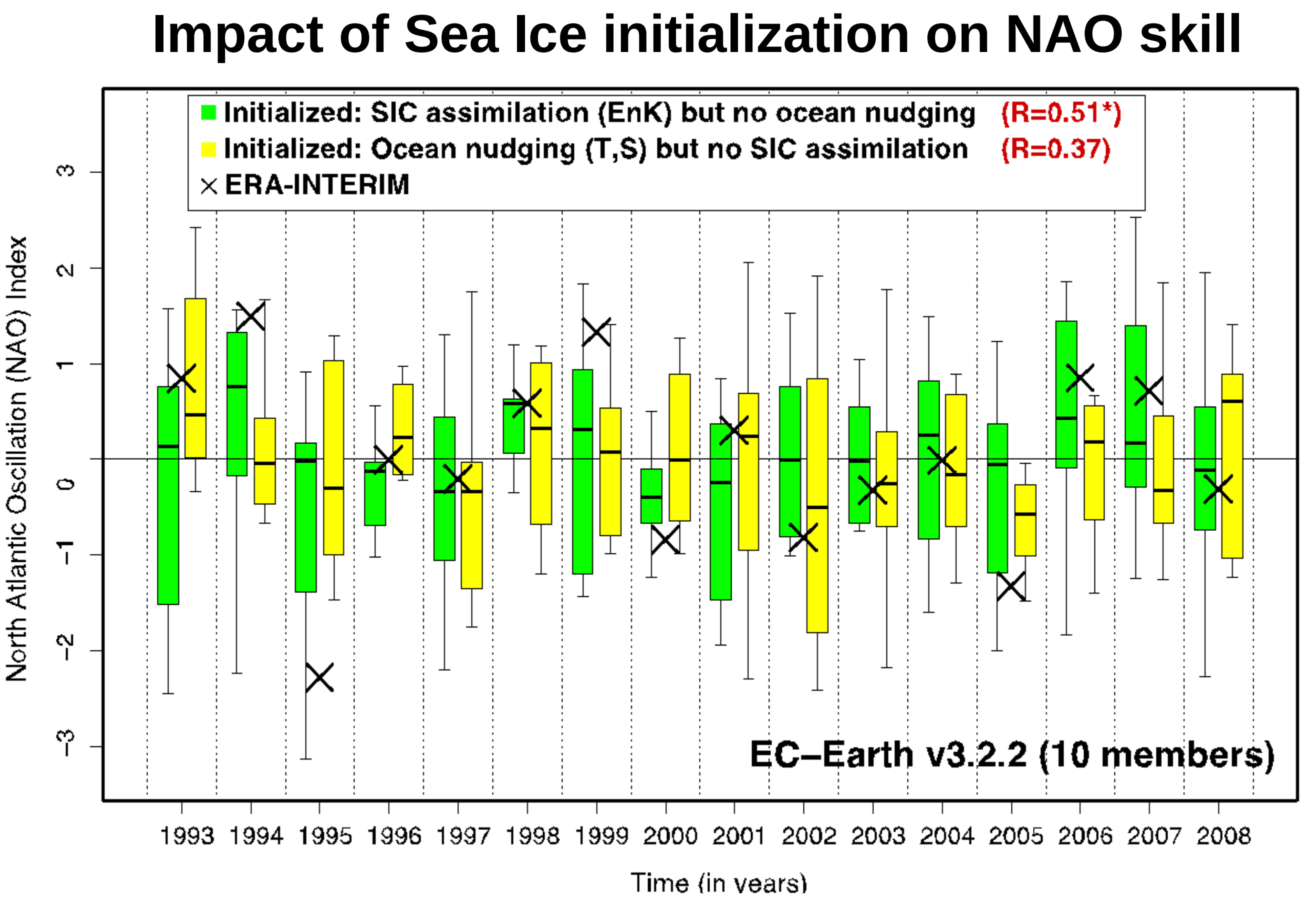
Impact of ice initialization

Seasonal Hindcasts with EC-Earth v3.2.2 [1993-2014]



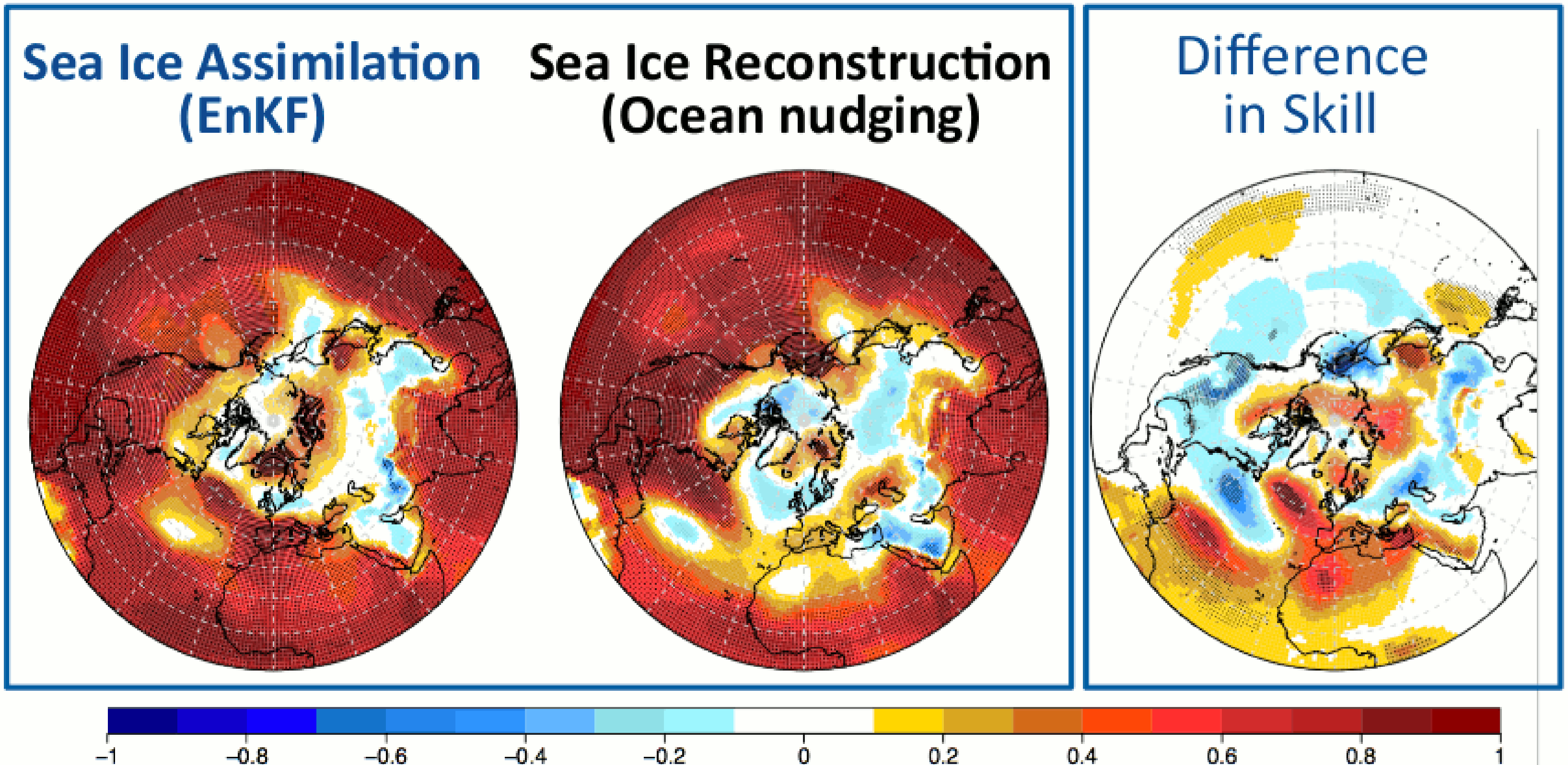
This improvement could potentially come from enhanced skill in the NAO

J.Acosta

Impact of ice initialization

Seasonal Hindcasts with EC-Earth v3.2.2 [1993-2014]

Impact of Sea Ice initialization on Surface Temperature in DJF

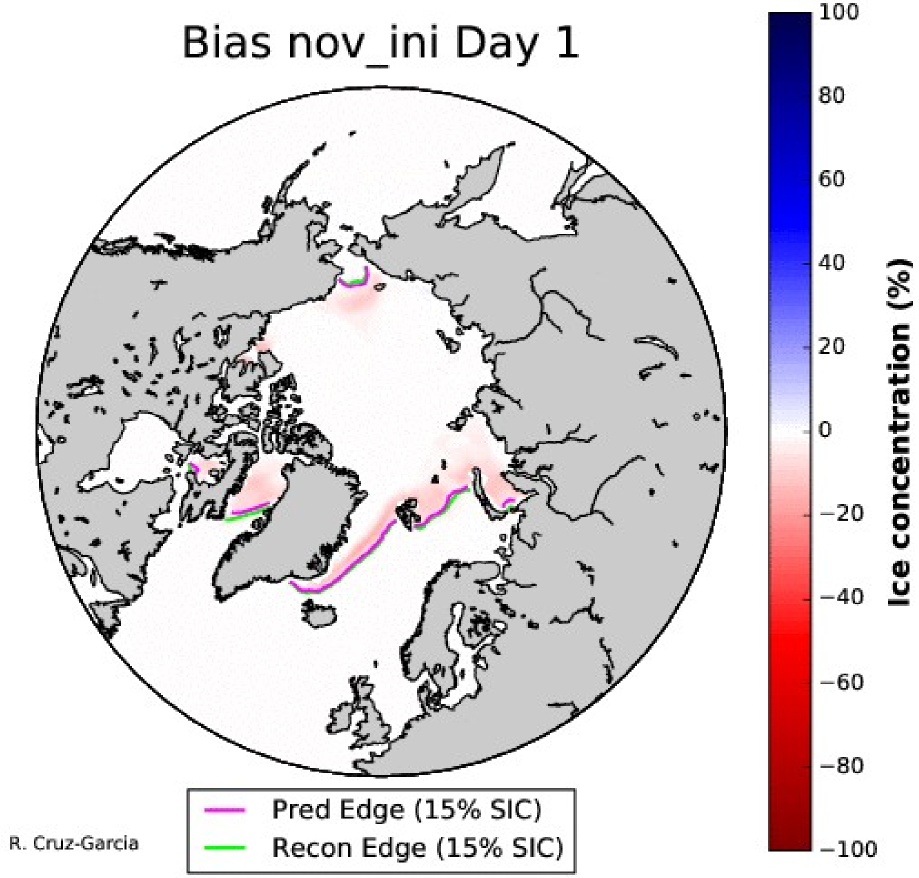


A better sea-ice initialization can improve the skill in the Mediterranean area and Scandinavia

J. Acosta

Impact of ice initialization

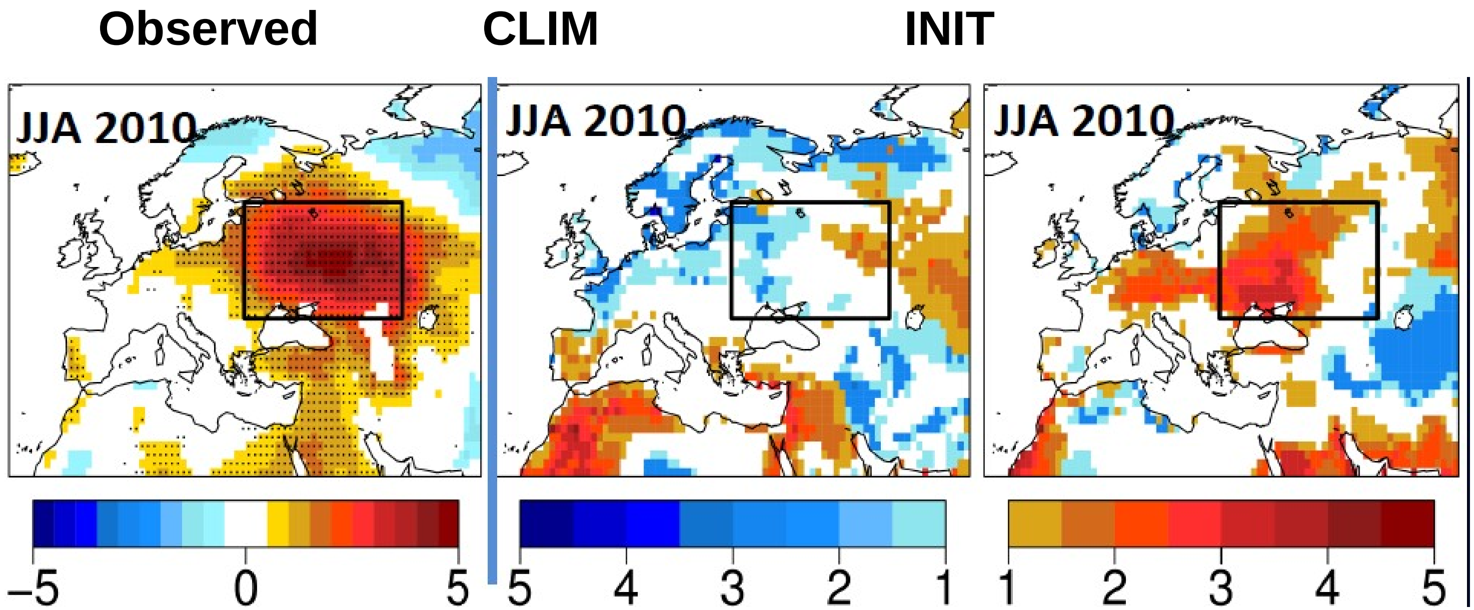
Seasonal Hindcasts with EC-Earth v3.2.2 [1993-2014]



R. Cruz

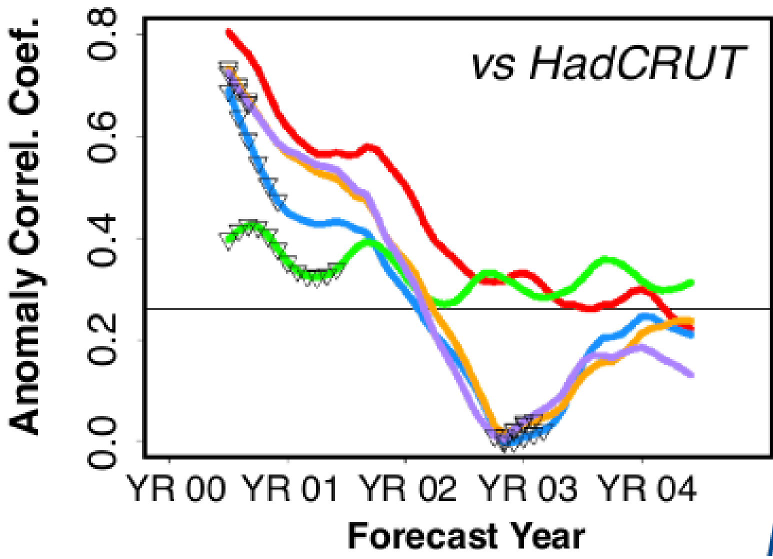
Impact of land initialization

Seasonal prediction of Russian heat wave initializing observed land-surface (INIT) conditions and climatological (CLIM) conditions. Land-surface initialisation matters.



Predictability from volcanic eruptions

Skill in mean global surface temperature



Menegoz et al 2018

Decadal Hindcasts
[1961-2001]

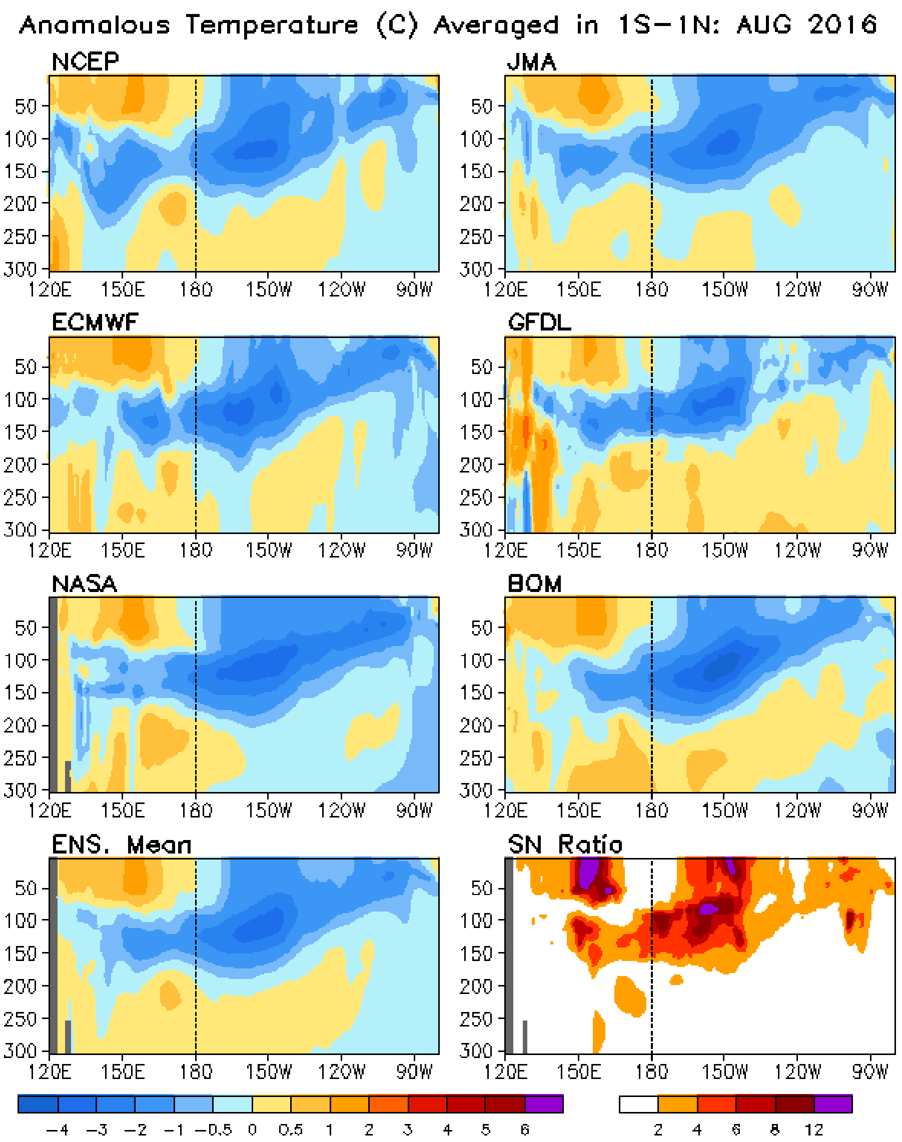
Major Eruptions:

Agung (1963)
El Chichón (1982)
Pinatubo (1991)

Volcanic eruptions can provide skill in mean global surface temperature for up to 2 years

Initial conditions uncertainty

- Real-time ocean analysis comparison. Temperature anomalies along the Equator based on 1981-2010 climatology.
- Large spread in real-time initial conditions



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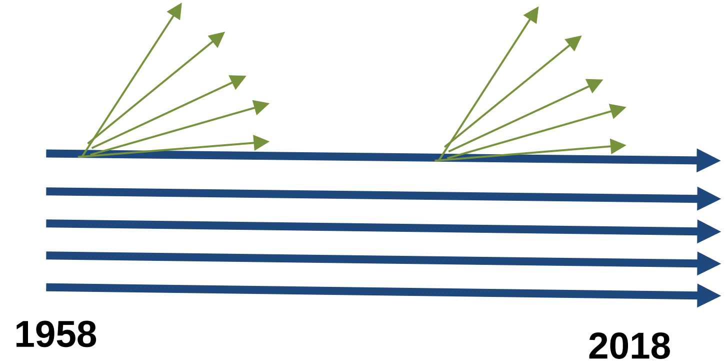
http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html

Shock and drift characterization

Spinup-nudg
1958-1975

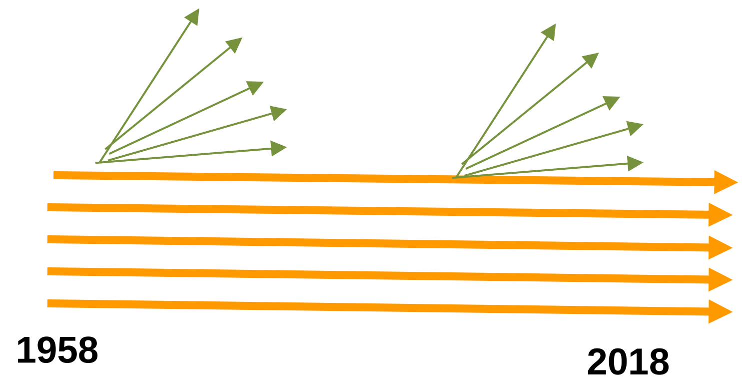
Reconstruction I

SSS and SST surface restoring
3D nudging



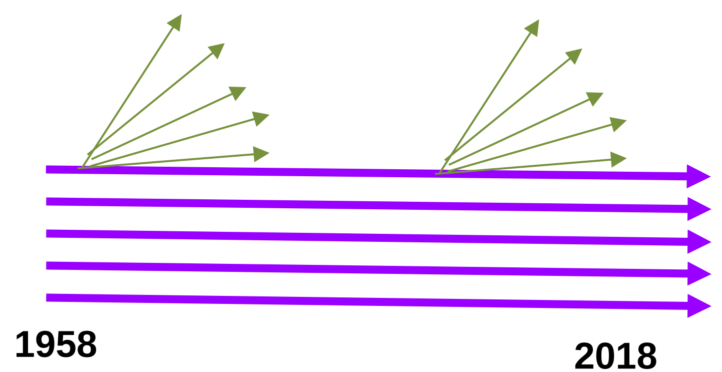
Reconstruction II 1958-2018

SST surface restoring
3D nudging



Reconstruction III 1958-2018

SSS and SST surface restoring



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Generation of initial conditions

- Initial Conditions
- Reconstructions: (e.g. AMOC/ Sea Ice/ Biogeochemistry)

Surface nudging

1) Both in SSS and SST
2) Only in SSS
3) Only in SST

No Equatorial band
Specific basins

↔

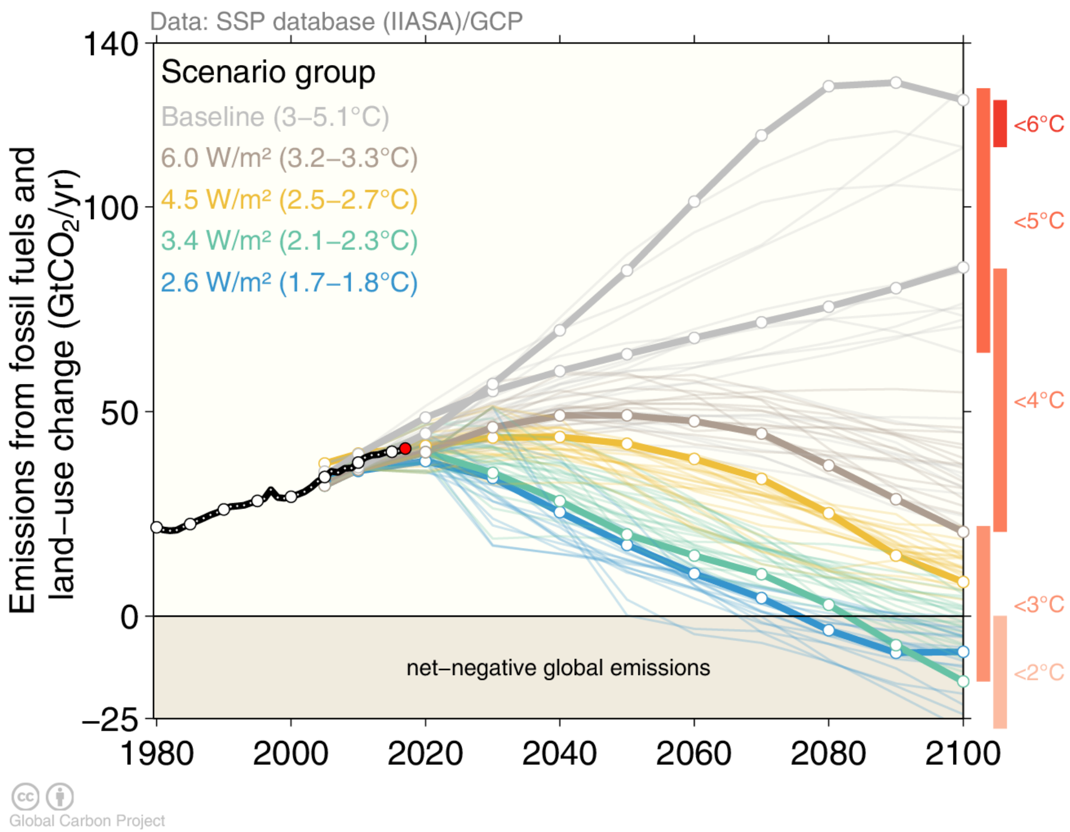
3D nudging

1) Both in Salinity and Temperature
2) Only in Salinity
3) Only in Temperature

Globally
Specific basins

Predictability of ocean biogeochemistry

Pathways to avoid 2° degree of warming: CO2 emissions need to decline rapidly by 2050



Reliable predictions provide:

- Guidance on amount of emissions to cut
- Independent verification on CO2 data emissions

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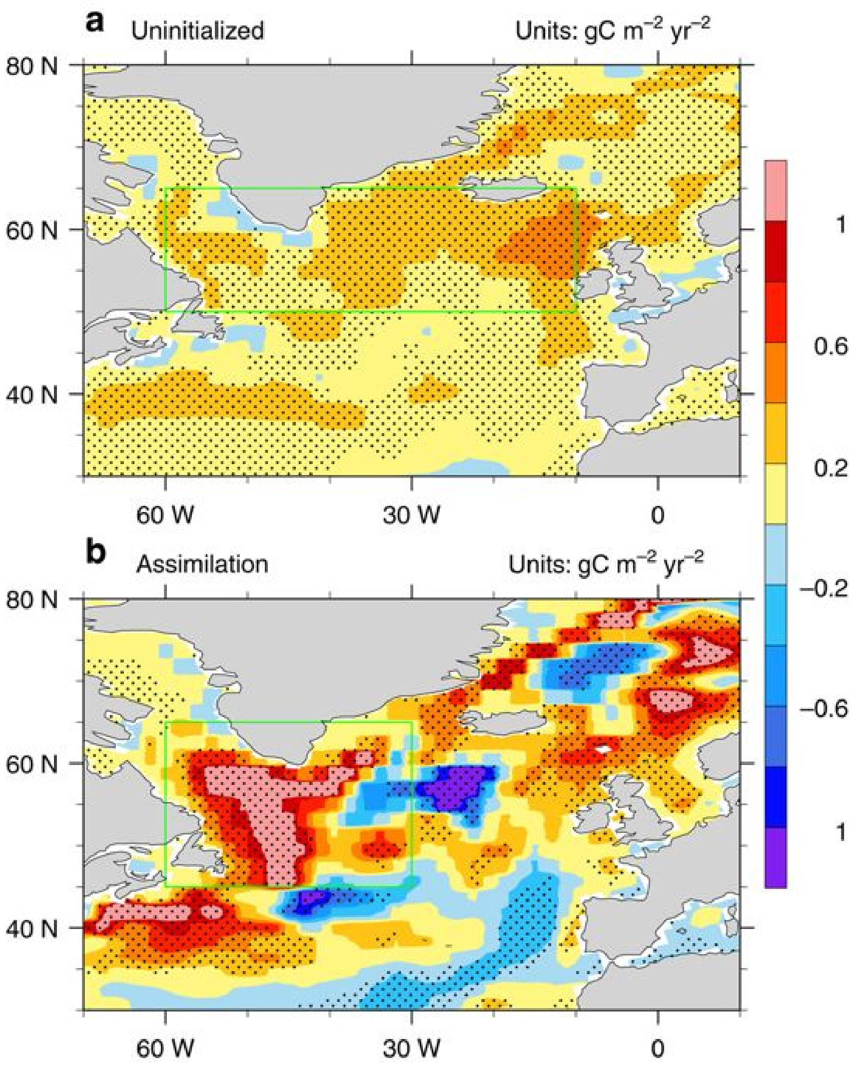
Predictability of ocean biogeochemistry



The world ocean is a major sink of anthropogenic carbon emissions.

- The oceanic carbon uptake also shows pronounced variability on **decadal timescale.**
- To what extent is the decadal variation of oceanic carbon uptake predictable?
- What are the underlying mechanisms in maintaining the predictability

Li et al. Nature, 2016

Predictability of ocean biogeochemistry

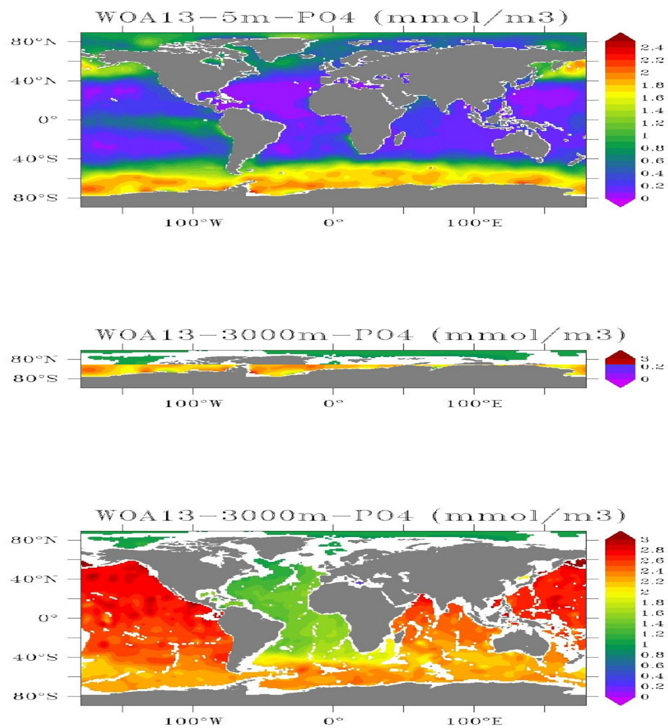
1st phase: generation of ocean biogeochemical ICs → Dynamical forcing ocean-only run (1984 DFS5.2)

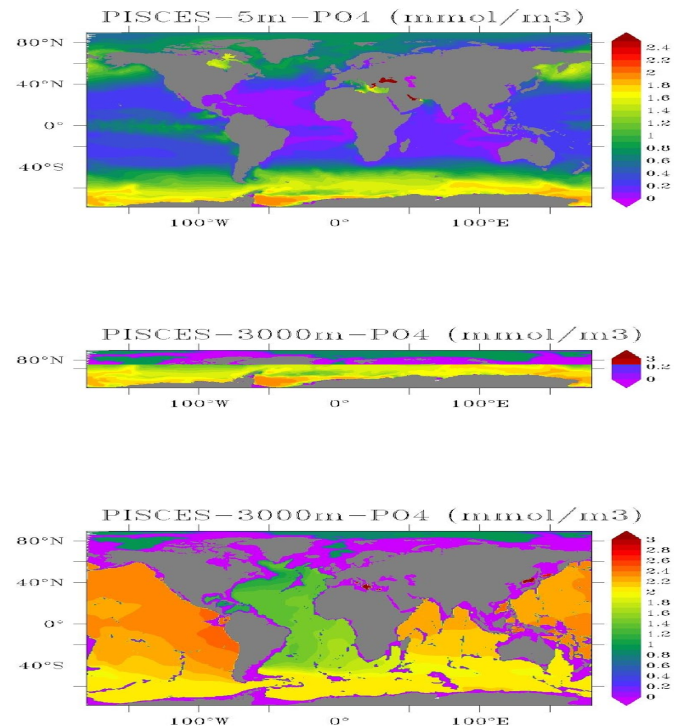
Observations (WOA13)

PISCES offline (year **2400)**

5 m

3000 m





Phosphate (mmol/m^3)

R. Bernardello

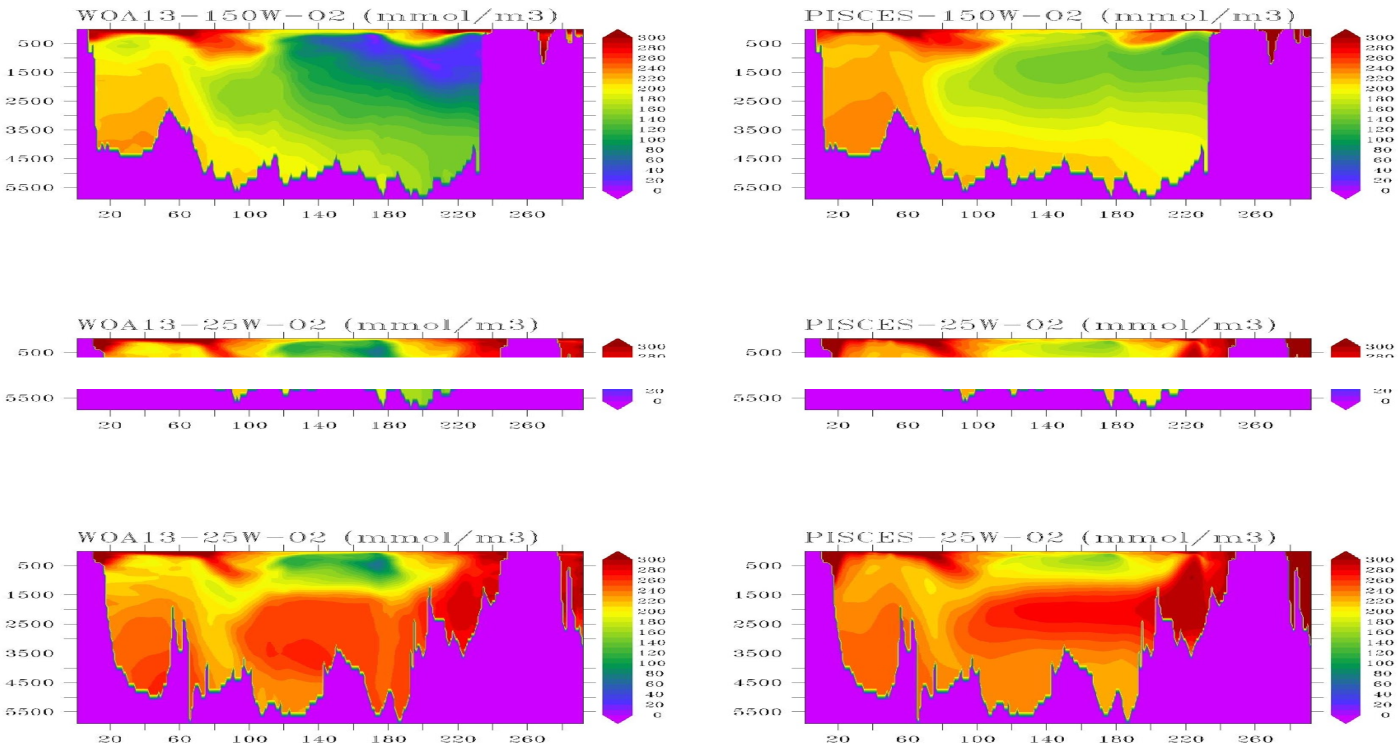
Predictability of ocean biogeochemistry

1st phase: generation of ocean biogeochemical ICs → Dynamical forcing ocean-only run (1984 DFS5.2)

Observations (WOA13) | PISCES offline (year **2400)**

Pacific O.

Atlantic O.



Oxygen (mmol/m^3)

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Prediction tool

Model Components

IFS (Atmospheric Model):

T255 (0.75º) ~80km
L91 (top 0.01hPa) ~mesosphere
IFS-HTESSEL (Land Model)

NEMO (Ocean Model):

Nominal 1° Resolution
L75 levels (thousands km deep)
PISCES (Biogeochemistry Model)

LIM (Sea-ice Model):

Multiple (5) ice category

IFS-HTESSEL

EC-EARTH
Global Coupled model

Initial Conditions

Atmosphere reanalysis (**ERA-Interim**)

Sea Ice reanalysis (**IC3/BSC**)

Land reanalysis (**ERA-Land**)

Ocean reanalysis (**ORAS4**)

EC-Earth at Marenostrum4

	T255ORCA1	T511ORCA025
Cores	1248	3456
Wall-clock Time (Hours) / year	19.12	4.2
Core Time (Hours) / year	1511.1	19748.6
Output size (GB) / year	9.1	500
Postprocessing Time (Hours) / year	7.1	26.1

One startdate, one member…if we have 10 members 5 stardates…

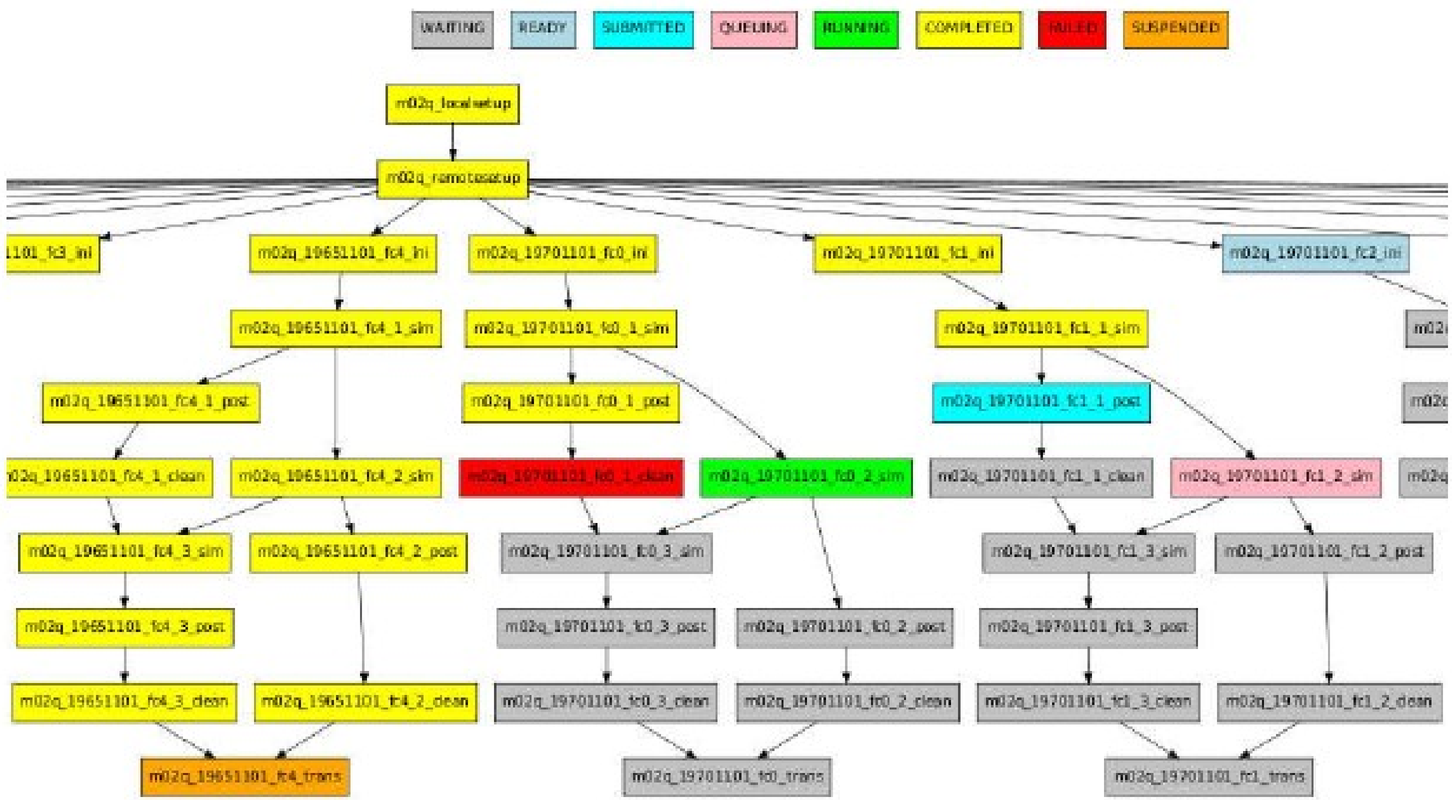
M.Costa

Workflow management - Autosubmit

What is Autosubmit: a python-based tool to create, manage and monitor experiments. It has support for experiments running in more than one HPC and for different workflow configurations

Workflow of an experiment monitored with Autosubmit:
Yellow = completed
Red = failed
Green = running
Blue = submitted
…

Domingo Manubens (BSC)



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Conclusions

- Decadal Climate Predictions (**ocean, ice, biogeochemistry**) rely on proper initialization

- Effort in generating accurate INITIAL CONDITIONS (IC) to run decadal predictions

- Predictions can be skillful despite the model's systematic errors, thanks to the beneficial effect of initialization

- Initial conditions uncertainty taken into account in ensemble systems.

- Good observations of the whole system are absolutely fundamental for accurate predictions.

- IC will be uses to address the characterization of initial shock and drift and to initialize decadal predictions for DCPP

Thank you

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